IMPROVING LABOUR PRODUCTIVITY IN MASONRY WORK IN NIGERIA: THE APPLICATION OF LEAN MANAGEMENT TECHNIQUES

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The performance of local contracting firms is very important to any nation's economic growth. This performance is hitched on the firms' construction efficiency which can be improved by increasing productivity. Therefore this paper examines the analysis of labour output for masonry work in the construction of six bungalow buildings in Abuja metropolis. The objective was to determine the level of labour productivity of contractors handling the construction of bungalow buildings and to identify gaps in levels of productivity and reasons for the differentials. The computation of the performance indexes that is Project Waste index (PWI), Performance ratio and disruption Index (DI), it was learnt that about 50% of the projects studied were poorly managed. The projects had low productivity rating. The other 50% performed well. The PWI values computed for the project studied ranged from 0.0106 to 0.1940. It was observed that three of the projects had PWI values lower than 0.1 which is an indication of good performance and three had values greater than 0.1. Three of the projects had Performance ratio (PR) value of 1.1389, 1.1689 and 1.9662 which showed poor performance. It was observed that low outputs were accomplished with high labour inputs. Other factors found out by direct observation for the non performing projects were distance of materials from work stations, system of daily payment method without adequate supervision and shortages of materials on site. It was recommended that the site managers of each of the non performing projects should learn reasons for gaps and make necessary adjustments in order to improve performance by raising labour productivity. It was also recommended that the lean benchmarking task should not be once for all exercise among the firms investigated but should be a continuous practice until the best practice height is attained.

Keywords: indigenous firms, labour, management, performance, productivity, project

INTRODUCTION

In Nigeria, building construction firms are usually categorized by several criteria. The classifications are mostly done on the scope of operation, ownership and management control. Idoro 2007 cited in Idoro 2010, defines "indigenous contractors as those contractors that are fully owned and managed by Nigerians, while the expatriate contractors in order words referred to as foreign contractors are mainly

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private firms that are jointly owned by Nigerians and foreigners but solely managed by expatriates".

The indigenous ones need careful attention and development because of the contribution of this sector to social and

economic development in the nation especially in the areas of job formation, 'entrepreneurship', wealth dispersal, financial effectiveness in deployment of resources, elasticity to market demands, distribution of development, "economic and political independence, and innovation" (Olugboyega 1998).

Olugboyega 1995, Enshassi *et'al* 2007 and Idoro, 2010, identified the preference of foreign contractors to their indigenous counterparts in the awards and execution of contracts. This is borne out of the fact that the later lack managerial exposure, are deficient in planning and management skills and exhibit low productivity. Other reasons for preference include problems of poor financial management, storage and retrieval of empirical data for the purposes of planning capital, labour and material resources.

Kerzner 1998; Bolles 2002; Dai and Wells, 2004, observed that inconsistent modern project management practices can influence a company's competitive position in the market place. They added that organsations failing to adopt consistent production management methods such as lean (benchmarking) principles regularly lose market share to peer companies that have institutionalised modern management techniques. They further pointed out that firms or organisations that delay in adopting formalized practices suffer specific consequences, including failure to learn from shared experiences, late and over budget projects, and low labour productivity.

Andersen and Petterson (1995) had earlier suggested the application of benchmarking technique to accelerate change in attitude and behaviour in an organisation. In view of the fact that it is a mechanism for "improvement and change", it will further help an organisation to search for industry best practices that will bring about superior performance by examining the performance and practices of other firms. There is the problem of lack of existing benchmarks for the local construction industry resulting in low productivity. There is also the problem of unwillingness of the local firms to embrace change mechanism perhaps because of the contractor's operating environment (Ofori, 1991). Therefore to complement previous government efforts to promote and develop indigenous contractors (Ofori, 1991; Olugboyega 1995 and Olugboyega 1998) there is the need to develop labour productivity benchmarks for indigenous firms in Nigeria, if not nationally but within a benchmarking club of firms.

BENCHMARKING

Benchmarking originated in the manufacturing industry as systematically and continuously measuring and comparing the firm's business and management processes against best practice in the same field (Harris and McCaffer, 2001).

Benchmarking has been identified as one of the principles of lean construction (Osman and Abdel Razek 1996). Benchmarking therefore can be defined as a systematic and continuous measurement process; a process of continuously measuring and comparing the output of one organisation to the output of another organisation anywhere in the world to acquire information which will assist the organisation to improve its operation or productivity (Koskela 1992; Madigan 1997). In another words, benchmarking is said to be the continuous process of measuring products, services and practices against the toughest competitors or those recognized as industry leaders (Camp 1989). From this definition, benchmarking measurement can be applied to products, production, process, services (labour) and practices. "The term benchmarking involves measurement which can be achieved by comparing internal and external practices and recording the significant differences to highlight the best practices that must be executed to realize superiority" (Straker 2006).

THE SIGNIFICANCE OF BENCHMARKING

Benchmarking accelerates the need for change in attitude and behaviour in an org organisation where it is practiced. It is a mechanism for "improvement and change". Benchmarking helps an organisation to search for industry best practices that will bring about superior performance by examining the performance and practices of other firms (Andersen and Petterson 1995).

For benchmarking to be successful there must be the need for available data for effective comparison and setting of a baseline. It also requires the provision of realistic and achievable targets coupled with the appropriate handling of the challenges of operational complacency. The exercise allows for the identification of areas of weakness and indicates what needs to be done to improve. It identifies potential areas of growth, raise attentiveness to performance and create a greater openness about strengths and weakness. Furthermore, it allows the operatives to visualize the improvement as a strong motivator for change. It can also help create an atmosphere conducive for continuous improvement and changes, and creates a sense of urgency from improvement (Amanda *et al.*, 2011).

Determination of Project Benchmarking Attributes

(i) Project Characteristics

Thomas *et al* (2002) and Thomas and Zavrski (1999b), explain the project characteristics as follows.

Total Work hours: Total Work hours are the summation of daily work hours in each project.

Total Quantities: Total quantities are the summation of daily quantities in each project.

Cumulative Productivity (wh/m^2): Total work hours (wh) over Total quantities (m^2).

Baseline Productivity: The baseline productivity is the best implementation a contractor can achieve for a particular project in other words is the best and most consistent productivity that the contractor achieved on a project.

Number of Abnormal Workdays: - According to Thomas and Zavrski, (1999b) the indiscriminate changeability in daily productivity figures when there are no disruptions is about twice the baseline productivity. Figures exceeding this boundary are usually the effect of transferable causes that is disruptions. An important measure of performance is the number of abnormal or disrupted days.

(ii) Project performance parameters (benchmarks)

Disruption Index: The first measure of labour performance (benchmarks) is the disruption index (D1). It is the ratio of the number of disruption workdays divided by the total number of observed workdays (Thomas and Zavrski 1996; Enshassi *et al.*, 2007).

Performance Ratio (PR): The performance ratio (PR) is the actual cumulative productivity divided by the expected baseline productivity (average values of baseline of all projects) Abdel – Razek *et al.*, 2007).

Project Management Index (PMI): The project management index sometime referred to as project waste index (PWI) is a dimensionless parameter that reflects the influence that project management has on the cumulative labour operations. It is expressed as the ratio of the difference between the cumulative productivity and baseline productivity over expected baseline productivity (Thomas and Zavrski 1999a, b). According to Abdel – Razek *et al* 2007, the baseline productivity occurs when the materials, equipment, and information flows are good and planning is adequate. As PMI is a measure of the difference between the actual and baseline productivity, it provides a measure of the impact of poor material, equipment and information flows, and inadequate planning. This makes it a measure of waste, which is one of the issues being addressed by lean construction. Reduced waste can lead to better flow and productivity. The lower the PMI value the better is the project management's influence on overall operation (Thomas and Zavrski 1999b). Mathematically, the PMI eliminates the productivity influence of complex design.

RESEARCH METHOD

Direct Activity Observation

The direct activity observation method was used in gathering data for the research work.

Six project sites were investigated in this work. All the sites sampled were located in Kado district area of Abuja which is one of the fastest developing areas in Abuja in terms of housing and infrastructure. It is an area recently approved by Federal Capital Development Authority (FCDA) for development. The data collected were gathered by observing work activity on site with the support of research assistants. Work done by every operative was noted on the daily recording sheets including times spent on the activities. This daily data collection form allowed for recording the direct work of the bricklayers, time for accomplishing such task, the number of crew involved whether skilled worker or unskilled worker. The data gathering form allowed the observers or research assistants to monitor and note critical factors of productivity affecting work men on site.

At the end of the masonry operation that is block laying, which varied from one site to the other, the daily data gathering forms were retrieved from the observers by the researcher for onward extraction of the daily input and output quantities. These values were entered into the data collation sheet, from which the daily labour productivities, baseline days and abnormal days were computed.

Assumptions

(1) All other factors of labour productivity are captured in the critical factors, which are stated in the instrument, identified in literature.

(2) The performance indicators used for assessing the projects were mainly project waste index, performance ratio and disruptive index.

Table 4.1, shows the days of observations, the gang size, work hours, daily quantity, daily labour productivity, baseline days and abnormal days. The total crew size was 81 workers and total work hours amounted to 559 hours. The figure for the total quantities (474m^2) was found to be lower than the total work hours. The project attributes were computed using the equations and steps described above in section 2.3.

The masonry work observed in project A lasted for nine days. The daily productivities ranged from 0.916 to 2.320whr/m^2. The project work has an average productivity of 1.180whr/m^2. The following days 2, 3, 4, 7 and 8 were identified as baseline days. The masonry task experienced two abnormal days which are days 6 and 9. The highest productivity scores were considered to define the baseline subset and the average of these five figures (0.916, 0.940, 0.940, 1.090 and 1.130 whr/m^2) represents the baseline productivity or benchmark in the project which is calculated to be 1.003whr/m^2.

In project B, the following were noted on the data gathering sheet, days of productivity monitoring, the gang size, work hours, daily quantity, daily labour productivity, baseline days and abnormal days.

DATA PRESENTATION AND ANALYSIS

Day	Crew size	Work hours (hr)	Daily quantity (m^2)	Daily productivity (whr/m^2)	Baseline days.	No of Abnormal days
1	4	32.00	18.50	1.730		
2	12	66.00	70.00	0.940		
3	15	105.00	112.00	0.940		
4	15	120.00	106.6	1.130		
5	12	90.00	65.00	1.386		
6	7	42.00	19.00	2.200		
7	4	32.00	35.00	0.916		
8	6	36.00	33.00	1.090		
9	6	36.00	15.50	2.320		
Sum	81	559.00	474.00	1.180	1.003	

The total crew size was 42 workers and total work hours amounted to 290hours. The figure for the total quantities (506.12m^2) was observed to be higher than the total work hours. The masonry work observed in project B lasted for six days. The daily productivities ranged from 0.505 to 0.752whr/m^2. The project work has an average productivity of 0.573whr/m^2. The following days 1, 2, 3, 4, and 5 were identified as baseline days. The masonry task experienced zero abnormal days. The highest productivity scores were considered to define the baseline subset and the average of these five figures (0.505, 0.563, 0.619, 0.554and 0.569whr/m^2) represents the baseline productivity or benchmark in the project which is calculated to be 0.562whr/m^2.

Project C, data sheet contains the days of monitoring, the crew size, work hours, daily quantity, daily labour productivity, baseline days and abnormal days. The total crew size was 50 workers and total work hours amounted to 370hours. The figure for the total quantities (516.40m^2) was seen to be higher than the total work hours. The masonry task monitored in project C was conducted for eight days. The daily productivities ranged from 0.450 to 1.077whr/m^2. The project work has an average productivity of 0.716whr/m^2. The following days 1, 2, 3, 6, and 7 were identified as baseline days. The masonry task experienced zero abnormal days. The highest productivity scores were considered to define the baseline subset and the average of these five figures (0.45, 0.607, 0.622, 0.711 and 0.716 whr/m^2) represents the baseline productivity or benchmark in the project which is calculated to be 0.621whr/m^2.

The computation of variables in project D, were similar to the earlier ones. The attributes were days of productivity monitoring, the gang size, work hours, daily quantity, daily labour productivity, baseline days and abnormal days. The total crew size was 54 workers and total work hours amounted to 341 hours. The figure for the total quantities (326m^2) was found to be lower than the total work hours. The masonry work observed in project D lasted for eight days. The daily productivities ranged from 0.705 to 1.400whr/m^2. The project work has an average productivity of 1.046whr/m^2. The following days 1, 3, 4, 7 and 8 were identified as baseline days. The masonry task experienced zero abnormal days. The highest productivity scores were considered to define the baseline subset and the average of these five figures, which are 0.705, 1.200, 1.280, 1.067 and 1.240whr/m^2, represents the baseline productivity or benchmark in the project which is calculated to be 1.098whr/m^2.

Similarly project E has the same project characteristics to projects A, B, C, and D. The attributes were days observation, the crew size, daily work hours, daily quantity, daily labour productivity, baseline days and abnormal days. The total crew size was 55 workers and total work hours amounted to 430 hours. The figure for the total quantities (355.07m^2) was discovered to be lower than the total work hours. The period of observation for project E was eight days. The daily productivities ranged from 0.640 to 1.684whr/m^2. The project work has an average productivity of 1.211whr/m^2. The following days 1, 2, 3, 5 and 7 were identified for project E as baseline days. The masonry task experienced zero abnormal days. The highest productivity scores that were considered to define the baseline subset were 1.055, 0.640, 1.270, 0.765 and 1.320whr/m^2, and the average of these five figures represents the baseline productivity or benchmark in the project which is 1.010whr/m^2.

Project F has the same variables as other projects sampled but different days of productivity monitoring, the gang size, work hours, daily quantity, daily labour productivity, baseline days and abnormal days. The masonry work observed in project F lasted for eight days. The total crew size was 54 workers and total work hours amounted to 463hours. The figure for the total quantities (227.3m^2) was for to be lower than the total work hours. The daily productivities ranged from 1.650 to 3.330whr/m^2. The project work has an average productivity of 2.037whr/m^2. The following days 3, 4, 5, 7 and 8 were identified as baseline days. The masonry task experienced five abnormal days. The highest productivity scores were considered to define the baseline subset and the average of these five figures (1.770, 1.650, 2.100, 1.870 and 2.210whr/m^2) represents the baseline productivity or benchmark in the project which is calculated to be 1.92whr/m^2.

DATA ANALYSIS AND DISCUSSION

Cumulative Productivity, Baseline Productivity and Abnormal Days

Table 5.1, is the summary of all projects monitored for the study. The table contains project codes, total work hour (hr), total quantity (m^2), total work days, cumulative productivity (whr/m^2), baseline productivity (whr/m^2) and number of abnormal days. The cumulative productivities for the six projects examined ranged from 0.573 to 2.037whr/m^2 while the baseline productivity ranged from 0.562 to 1.92whr/m^2. The cumulative productivity, for each project, is the total working hours in individual project divided by the total quantities in the same project. Projects 'A' and 'F' experienced abnormal days of two and five days respectively which means that the daily productivities of the abnormal days exceeded the

Table 5.1 Summary of Project Attributes of Sampled Sites

Project Code	*Total Work hour (hr)*	*Total quantity (m^2)*	*Total work days*	*Average Daily output (m^2)*	*Cumulative productivity (whr/m^2)*	*Baseline productivity. (whr/m^2)*	*No of Abnormal days*
A	559	479.00	9	53.22	1.180	1.003	2
B	290	506.12	6	84.35	0.573	0.562	0
C	370	516.40	8	64.55	0.716	0.621	0
D	341	326.00	8	40.75	1.046	1.098	0
E	430	335.07	8	41.88	1.211	1.010	0
F	463	227.30	8	28.41	2.037	1.920	5

Researcher's data analysis 2012

figure 2.070whr/m^2 which is twice the average baseline productivity for the six projects studied. The mean baseline productivity of the six projects under examination is the summation of the baseline productivity computed for each project divided by six. This amounted to 1.035whr/m^2. All daily productivity values were compared to this figure so as to determine if they are acceptable or abnormal. It was observed that two out of all the projects had abnormalities in some of the days monitored (Table 5.1).

Comparing the computed figure of the mean baseline productivity for the six projects with

the baseline productivity of each project, it could be seen that projects 'B' and 'D' have the best baseline productivity values of 0.562 and 0.621whr/m^2 respectively which are lower than the mean baseline productivity, whereas project 'C' has the worst baseline productivity which is 1.098whr/m^2. This figure is higher than the mean baseline productivity. Projects 'A' and 'E' have baseline productivities of 1.003 and 1.010whr/m^2 respectively which are slightly lower than the mean.

Table 5.2 Computation of Project Management index (PMI) and Performance Ratio (PR)

Project Serial Number	***Cumulative Prod. (whr/m^2)***	***Baseline Prod. (whr/m^2)***	***Project Management index (PMI)***	***Performance Ratio (PR)***	***Disruption index (DI)***
A	1.180	1.003	0.1708	1.1389	0.2222
B	0.573	0.562	0.0106	0.5531	0.0000
C	0.716	0.621	0.0916	0.6911	0.0000
D	1.046	1.098	0.0502	1.0100	0.0000
E	1.211	1.010	0.1940	1.1689	0.0000
F	2.037	1.920	0.1322	1.9662	0.6250

Source: Researcher's data analysis 2012

Disruption Index (DI); the disruption index for all projects monitored range from 0.00 to 0.6250. It should be noted that the lower the DI the less the project witnessed abnormal work days. Table 5.2 shows that projects B, C, D and E experienced zero abnormal days which means the projects performed well on the basis of no disruption. Project F was observed to be the worst projects because the DI value was very high which is greater than 0.4, which is the permissible benchmark for disruption index.

Performance Ratio (PR); the calculation of the performance ratios for the studied projects further gave an insight into the level of performance of the projects. It should be noted that the higher the PR the poorer the performance of the project. Whenever the performance ratio is greater than unity, it does not mean that the project or task is performing poorly rather the figure helps to make comparison against the best overall performance examined in all projects. Table 5.2 shows performance ratio for all the projects with project B having the lowest value (0.5531) of performance ratio. This means that the project performed well while project F had the highest value of performance ratio of 1.9662 which suggests poor performance in terms of productivity.

Project Waste Index (PWI) or Project Management Index; this is the contribution of the project management to the cumulative labour performance on the project. The lower the PWI the better the performance. Project B had the best PWI value of 0.0106 and project E had the worst PWI value of 0.1940 which indicates poor performance.

Table 5.3 Emergence of Best Practice Construction Firm

Source: Researcher's data analysis 2012

Table 5.3 presents a score card for all projects investigated. Project B was the best performing project

Project Code	Average Daily output (m^2)	Cumulative productivity (whr/m^2)	Baseline productivity. (whr/m^2)	No of Abnormal days	Project Waste index (PMI)	Perform ance Ratio (PR)	Disruption index (DI)
A	53.22	1.180	1.003	2	0.1708	1.1389	0.2222
B	84.35	0.573	0.562	0	0.0106	0.5531	0.0000
C	64.55	0.716	0.621	0	0.0916	0.6911	0.0000
D	40.75	1.046	1.098	0	0.0502	1.0100	0.0000
E	41.88	1.211	1.010	0	0.1940	1.1689	0.0000
F	28.41	2.037	1.920	5	0.1322	1.9662	0.6250

in terms of average daily output, cumulative productivity, baseline productivity, project waste index, performance ratio and disruptive index. The average daily output attained in project B was $84.35m^2$ which is the highest of all projects studied. An analysis of this value indicates that about $1.745m^2$ of masonry work in labour input per hour was achieved which means that greater output was achieved with little labour input.

In the case of the worst performed project that is projects A and F, the average daily outputs accomplished were $53.22m^2$ and $28.41m^2$ with the corresponding hourly output of $0.856m^2$ and $0.491m^2$ respectively which shows high labour content going by the indexes used in this study. An analysis of these values indicates that about $0.856m^2$ and $0.491m^2$of masonry work in labour input per hour were achieved for the two projects respectively which mean that lower outputs were achieved with higher labour inputs.

Gap Differential Analysis

The performance of a project is said to be high if the value of the project management index is low. This means the lower the value of PMI the better the performance. One of the major factors responsible for differential in performance is the crew size and make-up management among other factors. For instance, project A has a total of crew size of 81 workers with a total work hours of 559hours for an output of $474m^2$ of block work. This shows a higher input for a lower output. Therefore, to improve productivity the site manager has to increase output and reduce labour input. The situation is similar for projects E and F which also were poorly managed. Other factors found out by direct observation for the non performing projects were distance of materials from work stations, system of daily payment method without adequate supervision and shortages of materials on site.

There are also gaps among performing projects as shown in fig 1, which shows that there were little lapses in site labour management. Looking at the indexes computed for the projects, it means there is need for improvement in workforce management for some of the performing firms like projects C and D in order to fill in the gaps. Both have performance indexes lower than project B which creates room for improvement.

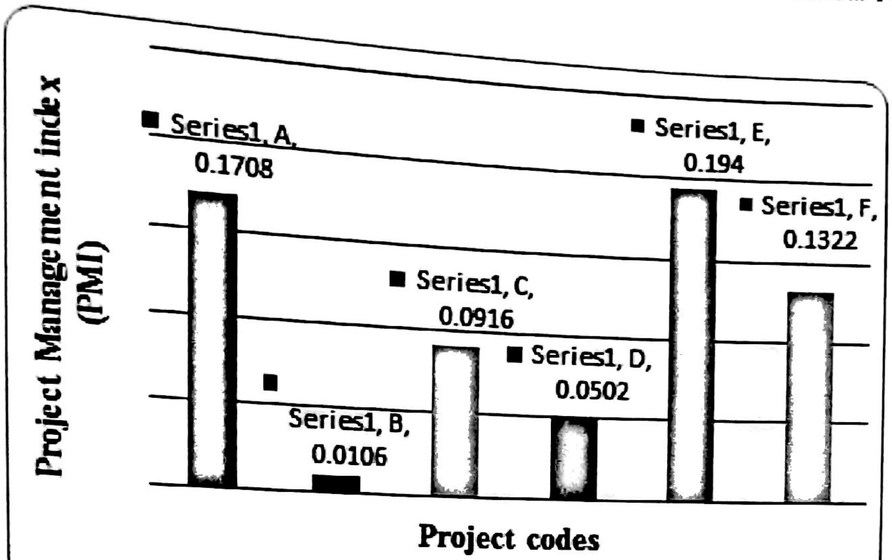

Figure1: Gap differential in performance

CONCLUSION AND RECOMMENDATIONS

Masonry work in six project sites in Abuja were investigated in this study in order to measure the daily labour productivity, cumulative productivity, baseline productivity, disruption index, performance ratio and project waste index. Also the average daily output was computed for all six projects.

Looking at all project benchmarks calculated for all the projects (Table 5.1), it is revealed that project B is the best performing project in terms of all the benchmark parameters computed which are average baseline productivity, disruption index, performance ratio and project waste index. The average daily output for project B was 84.35m^2 which is the highest of all projects studied. A breakdown of this value shows that about 1.745m^2 of masonry work in labour input per hour was achieved which indicates that greater output was realized with little labour input. This kind management resulted in high cumulative labour productivity of 0.573. Project B, by all standards from the performance indicators analysed in this study stands out as the best performing firm. Therefore, the site managers of each of the other projects have to learn reasons for gaps and make necessary adjustment in order to improve performance by raising labour productivity. It is also recommended that the benchmarking exercise should not be once for all task among the firms investigated but should be a continuous practice until the best practice level is attained.

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